Armillaria Root Disease

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Preface

Armillaria mellea (Vahl ex Fr.) Kummer [Armillariella mellea (Vahl ex Fr.) Karst.] causes a root disease of conifers and hardwoods province wide up to about the 56th parallel. Over this range, damage caused by the disease varies from minor mortality in young coastal plantations to mortality throughout the rotation, resulting in stand openings, in forests of the southern interior (Fig).

In British Columbia, there are several root disease fungi that cause similar symptoms and damage; however, each disease has specific management prescriptions. It is essential, therefore, that forest managers recognize the signs and symptoms that distinguish A. mellea from other root diseases, particularly *Phellinus weirii* (Murr.) Gilbertson (Wallis 1976).

This report, describing the biology, signs and symptoms, damage and distribution, and management options for A. mellea, is intended for foresters responsible for management of A. mellea-infested stands. Additional information and assistance with recognition of A. mellea, training of personnel or layout and monitoring of control projects may be obtained from Canadian Forest Service, Pacific Forestry Centre, 506 West Burnside Road, Victoria, B.C.

Coastal Forests Damage and Distribution

Although present in all coastal biogeoclimatic zones (Krajina 1965), Armillaria root disease is found more frequently in the Douglas-fir and hemlock zones than in the subalpine. In plantations and natural regeneration, mortality caused by A. mellea begins at about age 5, reaches its maximum at age 10 to 15 and is rare after age 25. Groups of one to five trees are killed over a number of years; incidence of killed trees rarely exceeds 2 to 3% and is usually below 1% of the stand. Stand openings created by A. mellea-caused mortality are rarely large enough to be significant by stand age 40 (Johnson et al. 1972).

As tree resistance increases with age, advance of root and root collar infections is checked and callusing begins. Often, lesions at the root collar are completely healed over, enclosing a small area of decayed wood.

Southern Interior Forests Damage and Distribution

In the Nelson and Kamloops forest regions, particularly in the Douglas-fir and cedar-hemlock

zones (Krajina 1965; Utzig et al. 1978), mortality begins at age 5 to 10 and continues throughout the rotation, causing unstocked or understocked openings. In ten A. mellea - affected stands, aged 40 to 225 years, the percentage of dead and infected conifers ranged from 3.6 to 30 (mean 14) and the percentage of stand area occupied by disease centers ranged from 8 to 32 (mean 22). Disease centers in three of these stands were large, 0.2 to 0.3 ha, and few in number, 0.25 to 0.5 centers per ha, and were the result of coalescence of adjacent centers. In the remaining seven stands, centers were smaller and more numerous.

Within disease centers, up to 95% of trees of commercial conifer species are infected or have been killed by A. mellea. The vegetation that occupies openings varies, depending on aspect and moisture. For example, on a dry south aspect, openings are occupied by grasses and low shrubs, whereas on moist north or east aspects, openings are restocked by hardwoods, hemlock or cedar. In turn, these trees may be attacked when their roots contact an inoculum source.

The amount of damage that occurs in a stand depends primarily on the number and distribution of colonized stumps and roots carried over from the previous stand, age of the present stand, and tree species.

Recognizing Armillaria Root Disease

From a distance, root disease centers caused by A. mellea are similar to those caused by other root disease fungi. Unlike the rapid mortality caused by insects and abiotic factors, decline and mortality in root disease centers occur over several years. Dead trees are surrounded by trees showing crown symptoms. The first crown symptom, declining leader growth, is followed by thinning and yellowing of the foliage and, frequently, by a distress crop of small cones.

To determine the cause of decline or death, the lower bole, root collar and roots of the tree must be examined for signs of the fungus. Conifers attacked by A. mellea usually exude large amounts of resin through the bark of the lower bole, the root collar and the roots. Removal of bark from areas of resinosis exposes the characteristic white mycelial fans that develop between the bark and wood (Fig).

When a tree has been dead for a year or more, particularly on a dry site, it is often necessary to look below ground for subcortical mycelial fans. Impressions of mycelial fans in hardened resin remain for several years after the disappearance of the fans.

Although external signs of A. mellea are absent from the lower bole of hardwoods, subcortical mycelial fans are usually well developed.

In autumn, usually after the first heavy rains, the mushroom fruiting bodies of A. mellea, which vary in size and shape, appear around the root collar and on the ground around diseased trees (Fig); they are always attached to infected woody tissue.

Disease Development

The life cycle of A. mellea has a parasitic phase, during which new food bases are colonized, and a saprophytic phase, in which the fungus utilizes the food base for growth. During the latter phase, it spreads from the food base to new hosts. Armillaria mellea can survive for several decades in large roots and stumps of trees killed by the fungus or invaded as they decline after cutting. It is in this residue that the fungus survives from one rotation to the next.

The mode of spread from a food base to a potential host and the subsequent development in the host are different in coastal forests from those in the Nelson and Kamloops regions.

Coastal Forests

Spread in coastal forests occurs primarily by rhizomorphs, although it has been observed by root contact. Rhizomorphs are root-like in form, have a white core with a red-brown to black outer rind and are usually 1 to 2 mm in diameter; they grow freely through soil but are attached to and dependent on the food base for nutrients.

Following contact between a rhizomorph growing tip and a potential host, the rhizomorph grows over the root surface and, at intervals, becomes firmly attached. At points of firm attachment, a branch of the rhizomorph penetrates the bark (Thomas 1934). On susceptible hosts, A. mellea continues to colonize the outer bark. Death of inner bark and cambium begins at or near the point of initial penetration and occurs in advance of mycelial fans. In conifers, resin is produced around the point of infection at an early stage and the area of resinosis increases as the fungus spreads in the bark. When a root is girdled by A. mellea, mycelial fans spread rapidly in the cambium of the distal portion, while in the part proximal to the girdle, ectotrophic growth in the outer bark and death of bark and cambium precedes spread of mycelial fans in the cambium. The host is killed by girdling of the root collar.

Conifers older than 15 years show increasing resistance to A. mellea root infections. Spread is often checked; however, the fungus remains viable and may become active if host vigor declines.

Interior Forests

Interior trees less than 10 years old have been killed following rhizomorph-initiated infections in a similar manner to those in coastal plantations. However, although present in older stands, rhizomorphs are usually found on root surfaces and little growth in soil has been observed. In these stands, spread of A. mellea is by transfer of mycelium at points of root contact. Where contact occurs between infected and healthy roots, a mycelial fan colonizes the outer bark of the healthy root. Armillaria mellea grows proximally in the root up to 10 cm per year; the tree is killed by girdling of the root collar.

Host Susceptibility

All species of deciduous and coniferous trees in the southern half of B.C. are susceptible, in varying degrees, to attack by A. mellea.

Coastal Forests

In coastal forests, deciduous species show more resistance to infection than do conifers. Up to about age 10, conifer species show little difference in susceptibility. Planted trees are more susceptible than natural regeneration, due likely to the greater frequency of deformed root systems in the former (Buckland 1953). Between 10 and 25 years, there is a gradual increase in tree resistance to A. mellea. After age 25 to 30, mortality is rare; however, basal lesions, localized root lesions and small amounts of butt rot are not uncommon.

Southern Interior Forests

Mortality caused by A. mellea may begin at age 5 to 10 and continue throughout the rotation in interior forests. Observations in stands aged 40 years and older suggest the following ranking in susceptibility to killing.

Least Susceptible: Pinus ponderosa, Larix occidentalis

Moderately Susceptible: Picea spp., Thuja plicata, Pinus contorta (Fig), P. monticola, hardwood species

Most Susceptible: Abies spp., Pseudotsuga menziesii, Tsuga heterophylla

Management Proposals

The substantial differences in behavior and damage caused by A. mellea between coastal and interior forests require different approaches to the management of affected stands.

Coastal Forests

In coastal forest zones (Krajina 1965), Armillaria root disease causes a small amount of mortality in the first 20 years of the rotation. Johnson et al. (1972) reported that the disease will create few, if any, openings in vigorously growing Douglas-fir plantations which would accommodate a 40- to 50-year-old tree; this is also true for stands containing other species. Therefore, except that spacing should not be done within A. mellea centers, no management action is necessary.

Southern Interior Forests

In many stands in the Nelson and Kamloops Forest Regions, A. mellea causes significant damage. At each of the three phases of stand management, spacing, commercial thinning and final harvest, there is an opportunity to reduce losses. The following management proposals are intended to avoid treating diseased stands where the investment may not be recovered, to reduce losses from tree mortality in established stands and, wherever possible, to rehabilitate A. mellea-infested sites. Because it is not feasible to eliminate A. mellea from all infested sites,

management proposals include measures to live with the disease; for example, by regenerating the least susceptible species.

Before attempting management operations in interior stands containing Armillaria root disease, one must know accurately the amount and distribution of the disease. This is determined by using disease signs and symptoms described above and the survey technique developed by Bloomberg et al. (1980) for Phellinus weirii.

Spacing Phase

By age 15 to 20 years, small disease centers containing dead trees and those with crown symptom trees will be evident around stumps of the previous rotation colonized by A. mellea. If there are ten or more disease centers per ha, spacing is not recommended because, at best, it will only delay spread of the fungus for a short time and many trees intended for the final crop will be killed before rotation age. Where disease centers are few and scattered, space normally, except around disease centers, where trees should not be spaced or only the least susceptible species should be left.

Commercial Thinning Phase

Heavily infected stands of commercial thinning age should not be thinned and consideration should be given to harvesting the stand if net volume increment (growth minus mortality) is unacceptable. Lightly infected stands may be thinned; however, disease centers should receive special treatments, depending on the frequency of harvest or salvage operations in the stand, as follows:

a) When stands can be entered at 5- to 10-year intervals, salvage all dead trees and those showing crown symptoms and/or basal resinosis.

b) If the interval between stand entries is more than 10 years, remove all dead and symptom trees and those within 10 m of a tree showing crown symptoms and/or basal resinosis.

These treatments are intended to salvage current and future shortterm mortality, but will not prevent the spread of A. mellea. Measures should be taken at final harvest to control the disease.

In stands or parts of stands infested by A. mellea, partial or diameter limit cutting is not recommended. This practice leaves infected, small diameter trees that will eventually be killed; results in more rapid spread of the fungus in roots of harvested trees and leaves a large volume of inoculum in the soil, which will infect subsequent regeneration.

Regeneration Phase

The best opportunity to control Armillaria root disease occurs when the stand is harvested. It is

difficult to identify disease centers after a stand is cut; therefore, prior to harvest, tag or paint diseased trees. Broadcast slashburning will not reduce the amount of A. mellea inoculum in stumps and roots below ground; bark and soil prevent lethal temperatures from reaching the fungus.

Three management options for infested sites can be considered at final harvest.

Inoculum Reduction

Where terrain and soil type permit, remove all stumps and roots within disease centers and from a 20 m strip around centers. In stands with few centers, the operation may be combined with routine site preparation. When disease centers are distributed throughout the stand and occupy more than 20% of stand area, it may be less expensive to treat the entire area rather than individual centers.

For inoculum reduction to be successful, the stump and roots larger than 5 cm diameter by 30 cm long that contain A. mellea must be removed from the soil. A bulldozer fitted with a brush blade is best; root raking (optional) to a depth of 60 cm will break up any infected roots left in the soil, allowing soil fungi to rapidly replace A. mellea. It is not necessary to pile and burn stumps; they are not an inoculum source when left on the surface. Following stump removal, the area may be regenerated to the species best suited for the site.

Alternative Species

Plant or encourage regeneration of the most resistant species (see host susceptibility) adapted to the site. When disease centers are few and widely scattered, plant the centers and a 20-m-wide surround with this species and plant the remaining area normally. When centers are large and distributed throughout the stand, the entire area will require special treatment. No conifer species is completely resistant to A. mellea; hence, some mortality can be expected.

Take No Remedial Action Return

On certain sites, such as steep south aspects, inoculum reduction is not feasible and regeneration of alternate species may be difficult. The best prescription for these sites is to harvest merchantable timber and rely on natural regeneration.

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Figures

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Figure 237-0082. Young lodgepole pine killed by Armillaria root disease.

Figure 237-0081. Mycelial fan of Armillaria beneath the bark.

Figure 237-0083. Mushroom fruit body of Armillaria.